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AUSTRALIA

PATENTS ACT 1990

PROVISIONAL SPECIFICATION

FOR THE INVENTION ENTITLED:-

"A POWER SUPPLY FOR A COMMUNICATIONS MODULE THAT DEMANDS HIGH POWER DURING PREDETERMINED PERIODS"

The invention is described in the following statement:-

FIELD OF THE INVENTION

The present invention relates to a power supply and in particular to a power supply for a communications module that demands high power during predetermined periods.

The invention has been developed primarily for use with a GPRS communications module for a cellular telephone and will be described hereinafter with reference to that application. It will be appreciated, however, that the invention is not limited to that particular field of use and is also suitable for other communications modules such as a GSM module, a Mobitex module, a PCMCIA card, a Compact Flash card, a communications card or device for a notebook computer, a laptop computer or a Tablet computer, or a wireless LAN device – such as a desktop or other computer – or other wireless devices.

BACKGROUND ART

Known mobile communications modules, such as GPRS modules, are used in cellular telecommunication handsets. The modules include a number of integrated circuits that collectively function to allow information to be processed and transmitted in accordance with the required communications standard. In the case of GPRS telephone handsets the information is usually voice data, although non-voice data is transmitted similarly. For other applications, such as a dedicated communication card in a laptop computer, the information is usually other than voice data.

The circuitry typically included within a GPRS module is a digital signal processor that is responsive to the data that is to be transmitted for providing a modulation signal, an RF oscillator for providing a carrier signal, and a mixer for combining the carrier signal and the modulation signal to form a transmission signal. This latter signal if provided to an RF power amplifier that drives an antenna to wirelessly transmit the signal to a base station.

The communications module is provided with power from a battery module that generally includes a lithium ion or Lithium Polymer battery or a number of such batteries in parallel. The battery notionally provides a zero current voltage of about 3.6 V to the communications module, although this varies between about 4.2 V to 3.0 V over the discharge cycle. In some instances, the battery module includes protection circuitry for limiting the current provided by the battery. In any event, the battery module includes a

finite output impedance and, therefore, the supply of power to the communications module will be at a voltage less than the zero current voltage.

The communications standard for GPRS signals results in the communication module having two distinct power consumption modes, these being a standby or a low power mode – where transmission or reception of data is not occurring – and a high power mode – where transmission or reception of data is occurring. During the high power mode, the power consumption of the module is concentrated in pulses, the timing and duration of which are set out in the standard. For GPRS Class 10, the pulses are of 1.15 msec duration, and are separated by 3.45 msec gaps.

In the high power mode, the increased power consumption arises predominantly because of the RF power amplifier being active to drive the antenna or to amplify the signal received by the antenna. Typically, during transmission, the communications module draws about 1 to 2 Amps from the battery module to allow the antenna to be driven at about 2 Watts. However, as the power amp is typically has an efficiency of about 40% to 60%, it draws about 3.3 to 5 Watts. Typically, during reception, the communications module draws about 0.1 to 0.3 Amps from the battery module.

The design constraints for communication devices, and particularly for mobile communications devices such as cellular telephone handsets, is strongly driven to minimise the handset size while maximising the period between recharging of the battery. This suggests that the battery should have as high an energy density as possible. However, batteries of this type typically have a high time constant and are therefore compromised in their ability to provide the required voltage and current during the high power mode of the device and in particular during the pulses. Accordingly, the more usual compromise is to tolerate a lower power density but gain a shorter time constant.

In partial answer to this problem, it has been known to use a bank of parallel tantalum capacitors to assist the battery during the high power mode. While some small advantage is gained, this is usually not justified by the cost and bulk of these capacitors.

The design of wireless communication devices for wireless LANs, PCMCIA cards and the like, is driven to achieve the desired functionality while also minimising volume, peak power consumption and cost. The demands for increased functionality and wider bandwidth communication places an increased premium on PCB "real estate" and packaging volumes.

Any discussion of the prior art throughout the specification should in no way be considered as an admission that such prior art is widely known or forms part of common general knowledge in the field.

DISCLOSURE OF THE INVENTION

It is an object of the invention, at least in the preferred embodiment, to overcome or substantially ameliorate at least one of the disadvantages of the prior art, or at least to provide a useful alternative.

According to a first aspect of the invention there is provided a power supply for a communications module that demands high power during predetermined periods, the power supply including:

a battery module for providing the communications module with a supply voltage wherein, during the predetermined periods, the battery module provides a first current at a first voltage that is less than the supply voltage; and

a supercapacitive device in parallel with the battery module for providing the communications module with a second current during the predetermined periods such that first voltage is maintained above about 90% of the supply voltage.

According to a second aspect of the invention there is provided a power supply for a communications module that demands high power during predetermined periods, the power supply including:

a battery module for providing the communications module with a supply voltage wherein, during the predetermined periods, the battery module provides a first current at a first voltage that is less than the supply voltage; and

a supercapacitive device in parallel with the battery module for providing the communications module with a second current such that variation in the first voltage during the predetermined periods is less than about 5% of the supply voltage.

Preferably, the first voltage is maintained above about 92% of the supply voltage. Even more preferably, the first voltage is maintained above about 95% of the supply voltage.

Preferably also, the battery module includes a lithium ion battery and the notional supply voltage is about 3.6 V.

In a preferred form, the supercapacitive device is a single supercapacitor. More preferably, the supercapacitor has a capacitance of about 380 mF and an ESR of less than about 100 mΩ. Even more preferably, the supercapacitor includes two supercapacitive

cells connected in series, a package for containing the cells, and two terminals being connected to the respective cells and extending from the package.

Preferably, the communications module includes:

a processor being responsive to data for generating a first signal;

an RF oscillator for providing a carrier signal;

a mixer for modulating the carrier signal with the first signal to generate a transmission signal; and

a power amplifier being responsive to the transmission signal for driving a wireless transmitter during the predetermined periods to transmit the transmission signal.

Preferably also, the communications module is a GPRS module. In other embodiments, the communications module is a GSM or Mobitex module.

In a preferred form, the communications module is a mobile telecommunications module. More preferably, the communications module is a GPRS module or a GSM module. In other embodiments, however, the communications module is part of one of the following devices: a PCMCIA card; a Compact Flash card; a notebook computer; a laptop computer; a Tablet computer; or a wireless LAN device.

Preferably, the power demanded by the communications module in the predetermined period includes periodic pulses of high power demand separated by substantially uniform intermediate power demand. More preferably, the intermediate demand endures for about three times the duration of the high power demand.

According to a third aspect of the invention there is provided a power supply for a communications module that demands high power during predetermined periods, the power supply including:

a battery module for providing the communications module with a supply voltage wherein, during the predetermined periods, the battery module provides a first current at a first voltage that is less than the supply voltage; and

a supercapacitive device in parallel with the battery module for providing the communications module with a second current during the predetermined periods such that the difference between the first voltage and the supply voltage is less than about 300 mV.

According to a fourth aspect of the invention there is provided a power supply for a communications module that demands high power during predetermined periods, the power supply including:

a battery module for providing the communications module with a supply voltage wherein, during the predetermined periods, the battery module provides a first current at a first voltage that is less than the supply voltage; and

a supercapacitive device in parallel with the battery module for providing the communications module with a second current such that variation in the first voltage during the predetermined periods is less than about 200 mV.

Preferably, the battery module includes a lithium ion battery or a Lithium polymer battery and the supply voltage is about 3.6 V. More preferably, the difference between the first voltage and the supply voltage is less than about 250 mV.

In a preferred form, the battery module includes:

a rechargeable battery for providing a battery voltage;

two terminals across which the supply voltage is provided; and

protection circuitry disposed between the battery and the terminals for limiting the current drawn from the battery.

In other embodiments, the battery module comprises a battery.

Preferably, the communications module includes:

a processor being responsive to data for generating a first signal;

an RF oscillator for providing a carrier signal;

a mixer for modulating the carrier signal with the first signal to generate a transmission signal; and

a power amplifier being responsive to the transmission signal for driving a wireless transmitter during the predetermined periods to transmit the transmission signal.

Preferably also, the communications module is a GPRS module. In other embodiments, the communications module is a Mobitex module or a 3G module.

Preferably, the circuitry limits the peak current drawn from the battery. More preferably, the circuitry also limits the average current drawn from the battery during the predetermined periods.

Preferably also, the battery module has a predetermined output impedance and the supercapacitive device includes a predetermined ESR that is less than the output impedance. In embodiments where the battery module consists of the battery, the output impedance equates to the sum of the internal resistance of the battery. .

In a preferred form, the volume of the supercapacitive device is less than about 2.7 cc. More preferably, the supercapacitive device is a single supercapacitor having a packaged volume of less than 1.5 cc.

According to a fifth aspect of the invention there is provided a power supply for a communications module that demands high power during predetermined periods, the power supply including:

a battery module for providing the communications module with a supply voltage V_{sv} wherein, during the predetermined periods, the battery modules provides a first current i_b at a first voltage v_s that is less than V_{sv}; and

a supercapacitive device having a predetermined equivalent series resistance R_s and being in parallel with the battery module, the supercapacitor providing the communications module with a second current i_s during the predetermined periods such that, throughout those periods, $(V_{sv} - v_s) \leq R_s.(i_b + i_s)$.

Preferably, the battery module consists of a battery. More preferably, the battery is a lithium ion battery and V_{sv} is about 3.6 V. Even more preferably, $(V_{sv} - v_s)$ is less than about 300 mV. However, in other embodiments, $(V_{sv} - v_s)$ is less than about 250 mV.

Preferably, the supercapacitive device includes a single supercapacitor having a plurality of supercapacitive cells. More preferably, the cells are connected in series. Even more preferably, the cells are contained within the same package. However, in other embodiments, the cells are contained within separate packages.

According to a sixth aspect of the invention there is provided a power supply for a communications module that demands high power during predetermined periods, the power supply including:

a battery module having an output impedance and providing the communications module with a supply voltage wherein, during the predetermined periods, the battery module provides a first current at a first voltage that is less than the supply voltage; and

a supercapacitive device in parallel with the battery module and having an equivalent series resistance that is less than the output impedance, the supercapacitive device providing the communications module with a second current during the predetermined periods such that the first voltage is maintained at or above a predetermined threshold.

Preferably, the threshold is about 90% of the supply voltage. More preferably, the threshold is about 92% of the supply voltage. Even more preferably, the threshold is about 95% of the supply voltage.

Preferably also, the threshold is about 300 mV less than the supply voltage. More preferably, the threshold is about 250 mV less than the supply voltage. Even more preferably, the threshold is about 200 mV less than the supply voltage.

In a preferred form the battery module is comprised of a battery and the supercapacitive device is comprised of a supercapacitor. In other embodiments, however, the battery module includes a plurality of electrically connected batteries and the supercapacitive device includes a plurality of electrically connected supercapacitors.

Preferably, the battery module includes a battery, two terminals between which the first voltage is provided, and protection circuitry disposed between the battery and the terminals for limiting the first current. More preferably, the first current is limited to an instantaneous peak value. Even more preferably, the first current is limited to an average value during the predetermined periods.

According to a seventh aspect of the invention there is provided a power supply for a mobile GPRS communications module that alternates between a high power consumption mode and a low power consumption mode, the power supply including:

a battery module for providing the communications module with a supply voltage; and

a supercapacitor connected in parallel with the battery module, the supercapacitor having an equivalent series resistance of less than 100 mΩ, a capacitance of at least 300 mF and a volume of less than 2.7 cc.

According to an eighth aspect of the invention there is provided a power supply for a communications module that demands high power during predetermined periods, the power supply including:

a supply rail for providing the communications module with a supply voltage wherein, during the predetermined periods, the supply rail provides a first current at a first voltage that is less than or equal to the supply voltage; and

a supercapacitive device in parallel with the battery module for providing the communications module with a second current such that variation in the first voltage during the predetermined periods is less than about 5% of the supply voltage.

Preferably, the supply rail is connected to a battery module. However, in other embodiments, the supply rail is connected to a regulated power supply.

According to a ninth aspect of the invention there is provided a power supply for a communications module that demands high power during predetermined periods, the power supply including:

a supply rail for providing the communications module with a supply voltage wherein, during the predetermined periods, the supply rail provides a first current at a first voltage that is less than the supply voltage; and

a supercapacitive device in parallel with the supply rail for providing the communications module with a second current such that variation in the first voltage during the predetermined periods is less than about 200 mV.

More preferably, the variation in the first voltage during the predetermined periods is less than about 150 mV.

According to a tenth aspect of the invention there is provided a power supply for simultaneously supplying power to a power amplifier circuit and an oscillator circuit that provides an output signal, wherein the circuits collectively demand high power during predetermined periods and, during those periods, the power amplifier circuit demands temporally spaced pulses of high power, the power supply including:

a supply rail for providing the circuits with a supply voltage wherein, during the predetermined periods, the supply rail provides a first current at a first voltage that is less than the supply voltage; and

a supercapacitive device in parallel with the supply rail for reducing the variation in the first voltage during the predetermined periods such that the variation in the output signal is reduced.

According to an eleventh aspect of the invention there is provided a wireless telecommunications device having a communications module that demands high power during predetermined periods, the telecommunications device including:

a battery module having an output impedance and providing the communications module with a supply voltage wherein, during the predetermined periods, the battery module provides a first current at a first voltage that is less than the supply voltage; and

a supercapacitive device in parallel with the battery module and having an equivalent series resistance that is less than the output impedance, the supercapacitive device providing the communications module with a second current during the

predetermined periods such that the first voltage is maintained at or above a predetermined threshold.

According to a twelfth aspect of the invention there is provided a wireless telecommunications device having a communications module that demands high power during predetermined periods, the telecommunications device including:

a supply rail having an output impedance, the supply rail providing the communications module with a supply voltage wherein, during the predetermined periods, the supply rail provides a first current at a first voltage that is less than the supply voltage; and

a supercapacitive device in parallel with the battery module and having an equivalent series resistance that is less than the output impedance, the supercapacitive device providing the communications module with a second current during the predetermined periods such that the first voltage is maintained at or above a predetermined threshold.

Preferably, the wireless telecommunications device is a handset for a cellular telephone. More preferably, the communications module is a GPRS module, a GSM module or a Mobitex module. In other embodiments, however, the telecommunications device is a PCMCIA card or a Compact Flash card; or a notebook computer, a laptop computer, a Tablet computer, or a wireless LAN device that includes such a card.

According to a thirteenth aspect of the invention there is provided a wireless telecommunications device having a communications module that demands high power during predetermined periods, the telecommunications device including:

a battery module for providing the communications module with a supply voltage V_{sv} wherein, during the predetermined periods, the battery modules provides a first current i_b at a first voltage v_s that is less than V_{sv}; and

a supercapacitive device having a predetermined equivalent series resistance R_s and being in parallel with the battery module, the supercapacitor providing the communications module with a second current i_s during the predetermined periods such that, throughout those periods, $(V_{sv} - v_s) \leq R_s.(i_b + i_s)$.

According to a fourteenth aspect of the invention there is provided a telecommunications system including:

at least one base station; and

a plurality of telecommunications modules of one or more of the eleventh, twelfth and thirteenth aspects, the telecommunications modules selectively communicating wirelessly with the base station.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is a schematic illustration of a cellular telephone handset containing a power supply according to the invention;

Figure 2 is an enlarged schematic illustration of the power supply of Figure 1;

Figure 3 is a trace of the voltage and current waveforms for a battery module that is supplying a GPRS module that is operating in the high power consumption mode;

Figure 4 is a trace of the corresponding voltage and current waveforms for the battery module of Figure 3 when in parallel with eight 470 μF tantalum capacitors;

Figure 5 is a trace of the corresponding voltage and current waveforms for the battery module of Figure 3 when in parallel with a single 380 mF supercapacitor having an ESR of 70 mΩ;

Figure 6 is a phase diagram for an 8PSK modulation schema; and

Figure 7 is a schematic illustration of a power supply according to another embodiment of the invention.

PREFERRED EMBODIMENTS OF THE INVENTION

Referring to Figure 1, there is schematically illustrated a power supply 1 for a communications module, in the form of a cellular telephone GPRS module 2. This module demands high power during predetermined periods. Supply 1 includes a battery module 3 for providing module 2 with a supply voltage that, in this embodiment, is about 3.6 Volts. During the predetermined periods, module 3 provides a first current at a first voltage that is less than the supply voltage. A supercapacitive device, in the form of a single supercapacitor 4, is connected in parallel with module 3 for providing module 2 with a second current during the predetermined periods such that first voltage is maintained above about 90% of the supply voltage. That is, the first voltage is maintained above about 3.24 Volts.

Module 2 is part of a handset 5 for a cellular telephone and includes many electronic circuits, both integrated and surface mounted, that perform the required functions. For the sake of clarity a subset of the circuits are shown schematically. More particularly, module 2 includes an intermediate frequency stage that is controlled by a digital signal processor 7 that is responsive to a data signal relayed on an input bus 8 for

providing a modulation signal on an output bus 9. An RF oscillator 10 is included for providing a carrier signal on a line 11. Bus 9 and line 11 provide the modulations signal and the carrier signal to a mixer 12 which, in response, generates an 8PSK signal complying with the GPRS standard and which is provided on line 13.

In other embodiments, module 2 is part of a wireless personal digital assistant (PDA) or other wireless device be that a laptop or other computer or a standalone communications handset. In further embodiments, module 2 conforms to a different wireless communication standard than GPRS. Examples of such standards include GSM, Mobitex, 3G and the like.

The 8PSK signal on line 13 forms the input for a power amplifier 14. This amplifier is responsive to the input for providing an output signal to drive an antenna 15. The output signal is at a power level set out in the standard, and is generally about 4 to 5 Watts.

The transmission of data in accordance with the GPRS standard, as with most digital telecommunications standards, includes a series of transmission pulses of a defined duration that are separated by a defined period where no transmission occurs. For the GPRS signals, the transmission pulses are of 0.577, 1.154 or 2.308 msec duration and the intermediate periods are of 4.039, 3.462 or 2.308 msec duration respectively. During the pulses and the intermediate periods the power consumption of the circuitry contained within handset 5 is respectively in a high power consumption mode and a low power consumption mode. The raised level of power consumption in the high power consumption mode is due predominantly to the pulsed operation of amplifier 14. However, it is also when the other circuitry is most likely simultaneously active.

By way of example, a typical handset uses about 0.5 Watts during the low power consumption mode and about 4.5 Watts during the high power consumption mode. It will be appreciated that some variation occurs between handsets from different manufacturers.

Antenna 15 also receives incoming signals. While not illustrated in the drawings, these signals are passed to the input of an RF receive amplifier and amplified, and then passed to an input mixer for demodulation. Oscillator 10 or another similar oscillator provides mixer 12 with the carrier signal to allow the demodulation to occur. Accordingly, as with the transmission of data, there is considerable activity and power consumption occurring. However, in the case the receiving data, the typical current

drawn from module 3 is about 0.3 Amps as opposed to the 1 to 2 Amps required during transmission.

When handset 5 is in a standby mode – that is, not in the transmitting or receiving mode – the power requirements are minimal. Typically, when in the standby mode, the handset would draw about 0.05 to 0.1 Amps.

In this embodiment, handset 5 communicates wirelessly with a cellular base station 21 that is remote from the handset. In other embodiments, the handset communicates with other mobile devices instead of or in addition to station 21. It will also be appreciated that the communication between station 21 and handset 5 is two-way.

Station 21 is part of a larger cellular network that includes a plurality of spaced apart like base stations (not shown) and a plurality of handsets that selectively communicate wirelessly with each other.

Station 21 includes an antenna 22 for receiving the wireless signal provided by handset 5. This signal is passed to a power amplifier 23, and the amplified signal then provided on line 24 to a mixer 25. A local RF oscillator 26 generates a carrier signal at the frequency dictated by the standard – which corresponds to the frequency of the signal provided by oscillator 10 – and supplies this to the mixer 25 via line 27. The resultant signal from mixer 25 is placed upon a bus 28 and passed to an IF receive stage including a digital signal processor 29. Processor 29 then uses this signal to reconstruct or represent the data originally provided on bus 8.

In this embodiment, module 3 is self-contained in a housing (not shown) that is separate from, but releaseably mechanically interconnectable with handset 5. The module 3 also includes terminals 35 for electrically engaging with complementary contacts 36 of module 2 when the housing is interconnected with handset 5.

In other embodiments, module 3 is integrated with the other circuitry contained within the handset housing.

Module 3 includes two lithium ion batteries 37 and 38 that are connected in parallel for providing the supply voltage of 3.6 V at terminals 35. In other embodiments only a single battery is used, while in further embodiments more than two batteries are used. While batteries are the preferred energy storage means for portable devices – primarily due to the high energy density – it will also be appreciated that in some embodiments module 3 includes energy storage means other than batteries. For example,

means such as fuel cells, capacitors and other energy storage devices either alone or in combination.

Disposed between batteries 37 and 38 and terminals 35 is a protection circuit 39 for preventing undesirable current in the batteries. In this embodiment, circuit 39 caps the permissible current that is able to be drawn from the batteries. In other embodiments, circuit 39 also prevents the average current over of predetermined period from exceeding a predefined threshold. These steps are taken to minimise the risk of damage to the batteries in over-current conditions. In some cases, should such an over-current condition occur, circuit 39 shuts down the supply of current from the batteries. However, in other embodiments, the current is simply limited.

Over the discharge cycle of batteries 37 and 38 the zero current or supply voltage will progressively reduce. For a typical lithium ion battery, the supply voltage will be about 4.2 Volts when the battery is fully charged, and about 2.9 Volts when the battery is substantively spent.

In the present embodiment, the supercapacitive device is chosen to ensure that during the reasonable operational discharge life of the battery that the first voltage is maintained at or above a predetermined percentage of the supply voltage. This also has the effect of reducing the variation in the first voltage that occurs during the high power mode.

Conversely, in other embodiments, the supercapacitive device is chosen to reduce the variation of the first voltage that occurs during the high power mode, again, during the reasonable operational discharge life of the battery. This also has the benefit of allowing the difference between the first voltage and the supply voltage to be more tightly contained.

Supercapacitor 4 includes approximate dimensions of about 29 mm x 18 mm x 3 mm, giving a total volume of about 1.5 cc. It also has a capacitance of about 380 mF and an ESR of about 70 mΩ. This capacitance per unit volume is about two or three orders of magnitude greater than has been offered by tantalum capacitors.

Reference is now made to Figures 3 to 5 that illustrate the improved performance offered by an embodiment of the invention. More particularly, Figure 3 is a trace of the voltage and current waveforms for module 3 that is supplying a GPRS module 2 that is operating in the high power consumption mode. In this embodiment, the battery module is comprised of a LiIon battery having a capacity of 600 mAmp hours and an internal

resistance of about 250 mΩ. The top trace 41 in Figure 3 represents the voltage at terminals 35, while the bottom trace 42 represents the current drawn from the batteries. It will be appreciated that for these results there is no supercapacitive device connected in parallel with terminals 35. That is, Figure 3 represents one of the prior art arrangements.

In the high power consumption mode, as shown, the battery module 3 provides module 2 with a voltage of about 3.13 Volts as a load current is being drawn from the batteries. That is, the finite output impedance – the internal resistance – of the batteries 3 ensures that the supply voltage is less than the notional battery voltage. Moreover, during this high power consumption period, there are defined intervals – designated by reference numeral 43 – where amplifier 14 draws about 2 Amps. As intervals 43 commence, the battery voltage quickly falls by about 510 mV and then, throughout the interval, more gradually falls to about 551 mV less than the initial voltage. At the end of intervals 43 the battery voltage returns to the initial voltage, although there is some delay due to the time constant of the battery.

Corresponding traces 45 and 46 are provided in Figure 4, although in this case, the battery module is connected in parallel with eight 470μF tantalum capacitors. That is, a total capacitance of 3.76 mF is provided by these devices that have a collective volume, allowing for space between them when mounted on a PCB of about 1.5 cc and a packaged volume of about 0.13 cc each.

During corresponding intervals 43, the voltage provided at terminal 35 falls away quickly and then slightly less rapidly ramps down to 391 mV less than the initial voltage. At that point, amplifier 14 ceases drawing the transmission current and the batteries commence charging the capacitors. This charging only just occurs prior to the commencement of the next interval 43. The peak current drawn from the batteries falls from about 2 Amps, as is the case in Figure 3, to about 1.5 Amps. The remainder of the current drawn by the communications module is sourced from the tantalum capacitors.

Accordingly, the use of eight tantalum capacitors maintains the minimum voltage supplied during intervals 43 at about 160 mV better than would occur if no assistance was provided to the battery. The small quantum of this benefit, when compared with the expense of the capacitors and the considerable space that they occupy, is generally sufficient to ensure that such capacitors are not used.

It is evident from traces 45 and 46 that the tantalum capacitors have insufficient energy storage to fully assist the battery during intervals 43. While that may be possible

to overcome by placing more capacitors in parallel, the volume cost of providing that capacity is commercially unacceptable.

Corresponding traces 47 and 48 are provided in Figure 5, although in this case, the battery module 3 is connected in parallel with supercapacitor 4. As is evident from the traces, although there is a small decrease in battery voltage at the start of intervals 43, there is no significant voltage decay during those intervals. This is because supercapacitor 4 has sufficient capacitance to store the energy required to deliver the peak load for the duration of the interval. The voltage drop during the load has been reduced by 302 mV from 551 mV for the battery alone, to 249 mV for the battery in parallel with the supercapacitor. Additionally, the change in voltage at terminal 35 during the high power consumption pulse train has been reduced from 551 mV to 140 mV.

In the periods between intervals 43, the battery voltage is a little lower than is the case for the Figure 3 and 4 configurations. This is due to the charging current that is required for the supercapacitors. As batteries operate more effectively with more constant current drains, the use of the supercapacitor is advantageous.

Additionally, the ESR of the supercapacitor is low and, therefore, there will be very only low I^2R losses in this passive component.

The use of supercapacitor 4 provides a significant improvement in the load regulation to module 2 in a cost effective and space effective manner. While improved load regulation is an advantage for most applications, in the present embodiment additional benefits arise. Particularly, when amplifier draws the peak current in intervals 43 and thereby drags the voltage at terminal 35 down, this also reduces the supply voltage available to other circuitry within module 3. Of these, it has been found by the inventors that the frequency of the carrier signal produced by oscillator 10 is very susceptible to variation in response to changes in the supply voltage. Similar comments apply to the output signal of mixer 12, although the effect is of a lesser magnitude.

The use a supercapacitor in parallel with the existing power supply rail – which in the above embodiments is provided by a battery module – maintains the rail so as to reduce the variation in frequency of the carrier signal in comparison to that provided by the prior art methodologies.

Any frequency variation in the carrier signal manifests as a phase error at the receiver end. For the 8PSK modulation schema, which is represented in Figure 6, there is indicated the effect of phase error at a receiver. As the phase error increases, the ability

of the receiver to effectively reconstruct the original data is reduced. That is, phase errors due to poor supply rail regulation ultimately compromise the bit error rate of the transmission that is being made with module 2. Accordingly, as presently envisaged, the use of the preferred embodiments of the invention allows the bit error rates to be minimised over the operational life of the battery.

As presently understood, the embodiment of Figure 1 achieves this goal through one or more of the following:

1. By containing, during intervals 43, the variation in the voltage provided by module 3 to less than a predetermined threshold of the zero current supply voltage of module 2. Preferably, that threshold is about 5% and more preferably about 3%.
2. By maintaining the voltage provided to module 2 at more than a predetermined threshold of the zero current supply voltage of module 2. Preferably, the threshold is about 90%, although more preferably about 92%, and most preferably about 95%.
3. By containing, during intervals 43, the variation in the voltage provided by module 3 to less than a predetermined threshold. Preferably, that threshold is about 200 mV.
4. By using a supercapacitor with an ESR that is less than the output impedance of the power source. In the case where the power source is a battery, the ESR is less than the internal resistance of the battery.
5. By ensuring the supercapacitor provides sufficient energy storage so that the voltage decay during the peak load is less than or equal to the ESR drop of the supercapacitor. That is, that the voltage decay is less than the supercapacitor ESR x the peak load current.
6. By providing a supercapacitor of low volume with respect to the available capacitance.
7. By providing a supercapacitor with a low ESR. More preferably, the ESR is less than 100 mΩ. More preferably, the ESR is less than 70 mΩ.

An alternative manner of expressing point 5 above is as follows. A power supply for a communications module that demands high power during predetermined periods is defined as including:

a battery module for providing the communications module with a supply voltage V_{sv} wherein, during the predetermined periods, the battery modules provides a first current i_b at a first voltage v_s that is less than V_{sv}; and

a supercapacitive device having a predetermined equivalent series resistance R_s and being in parallel with the battery module, the supercapacitor providing the communications module with a second current i_s during the predetermined periods such that, throughout those periods, $(V_{sv} - v_s) \leq R_s.(i_b + i_s)$.

Preferably, the battery module consists of a battery. More preferably, the battery is a lithium ion battery and V_{sv} is about 3.6 V. Even more preferably, $(V_{sv} - v_s)$ is less than about 300 mV. However, in other preferred embodiments, $(V_{sv} - v_s)$ is less than about 250 mV.

An alternative embodiment of the invention, in the form of a power supply 51, is disclosed in Figure 7 where corresponding features are denoted by corresponding reference numerals. In this embodiment, supply 51 includes, rather than a battery module, a supply rail 52 that emanates from a regulator 53. This regulator is mounted to a PCMCIA card for a laptop or a desktop computer (not shown).

Regulator 53 has a specified current capacity that is limited predominantly by the design parameters of the card itself. That is, while a mains supply is available, the regulator is only allocated a small proportion of the available real estate and can therefore only effectively regulate a certain threshold of average power consumption. As with module 2, the load of the regulator is pulsed between a low power consumption mode and a high power consumption mode to effect the desired wireless transmission. For prior art power supply designs, the regulator typically has difficulty adequately performing during the peak periods. In the Figure 7 embodiment, however, the inclusion of supercapacitor 4 reduces the peak load on regular 53 such that it is able to operate within it design parameters.

The embodiments of the invention make use of low ESR and high capacitance per volume supercapacitors. This high volume efficiency ensures that effective packaging within the handset or other communications device is possible. This factor is paramount in the design and acceptance of portable devices. It also assists in the design of PC cards and other components including a communications module, as the increased space efficiency, and improvements to performance, allows more volume for other components.

Better load regulation provides many advantages, including increased run times, lower bit error rates, lower phase errors and the like. In particular, Figure 1 shows comparison of received and transmitted data to determine a Bit Error Rate (BER). The improved load regulation improves the performance of the oscillator and modulation

circuits, thereby reducing the phase error, and thereby reducing the BER. This enables longer battery run times – that is, increased discharge of the battery – before phase errors in module 2 become out of specification.

It will be appreciated by a skilled addressee, from the teaching herein, that in other embodiments supply 51 is associated with a wireless communications card that is disposed within a computer and which allows that computer to communicate with a wireless LAN. The computer is, in some embodiments, as desktop computer, although in other embodiments use is made of laptop or other computers.

Although the invention has been described with reference to specific examples, it will be appreciated by those skilled in the art that it may be embodied in many other forms.

DATED this 29th Day of August, 2002
ENERGY STORAGE SYSTEMS PTY LIMITED
Attorney: JOHN B. REDFERN
Fellow Institute of Patent and Trade Mark Attorneys of Australia
of BALDWIN SHELSTON WATERS

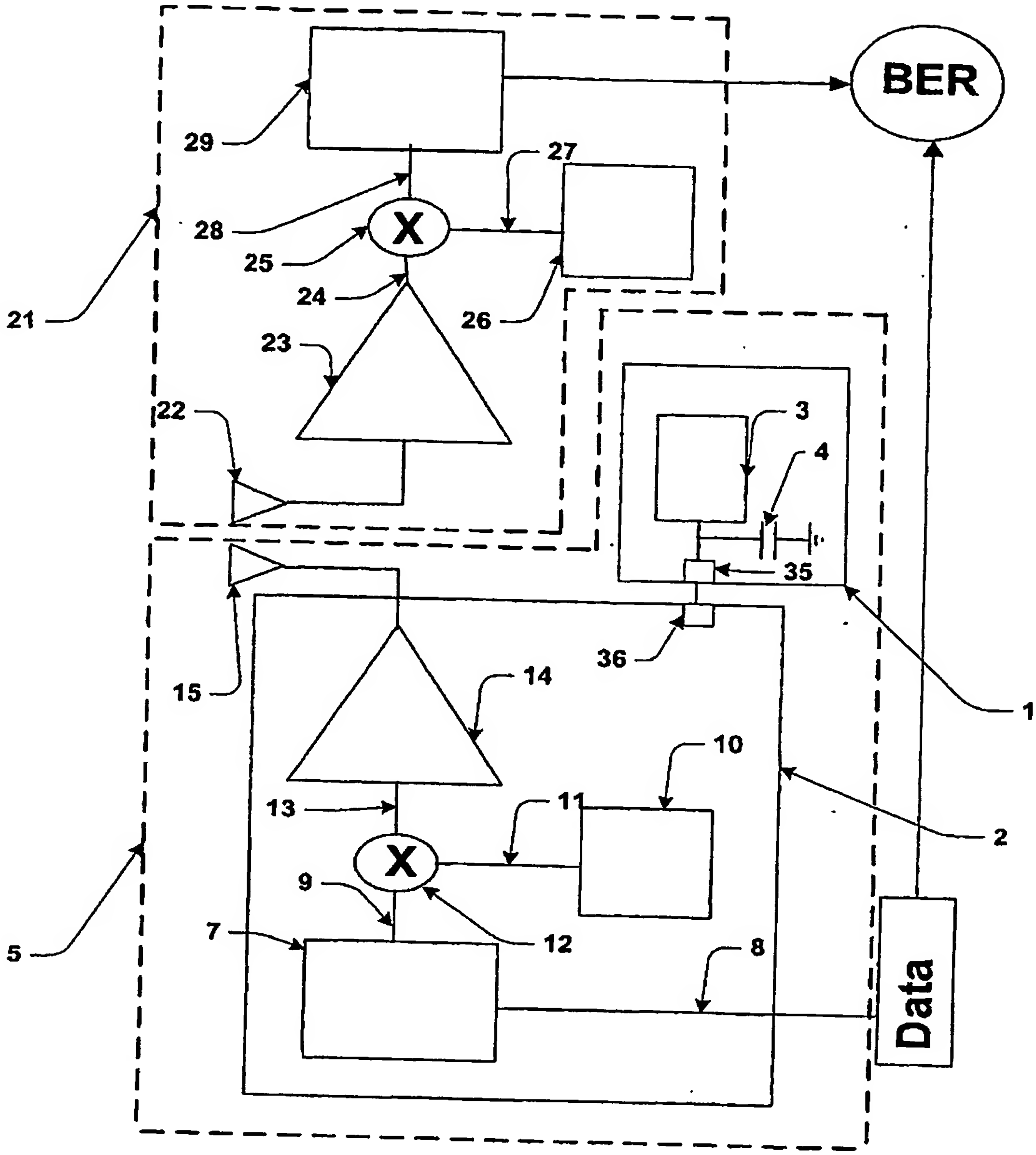


FIGURE 1

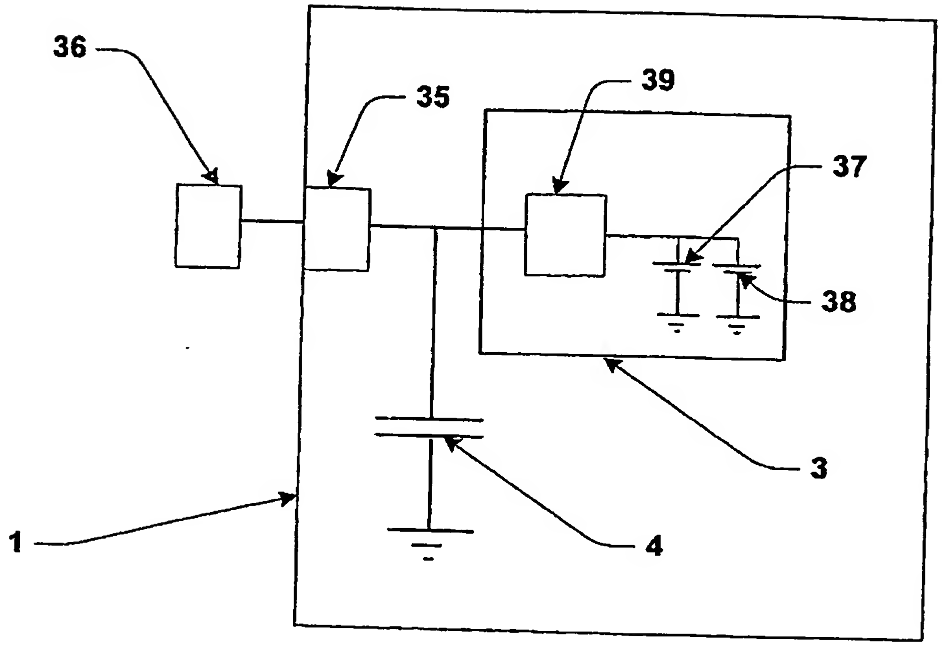


FIGURE 2

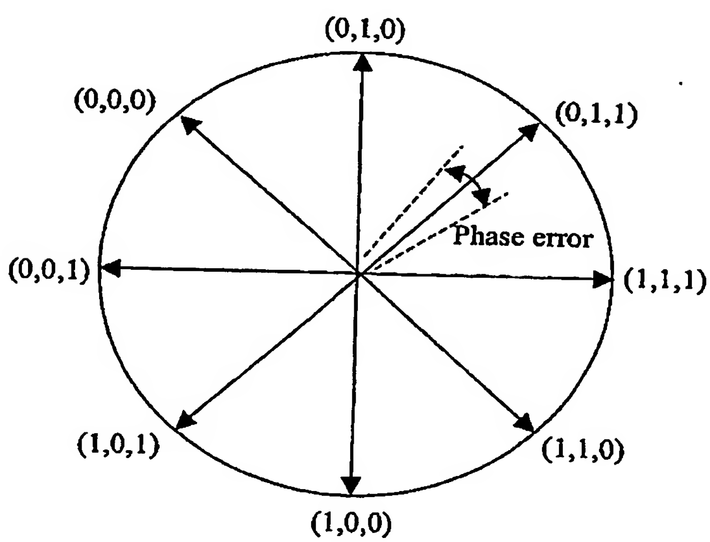


FIGURE 6

FIGURE 3

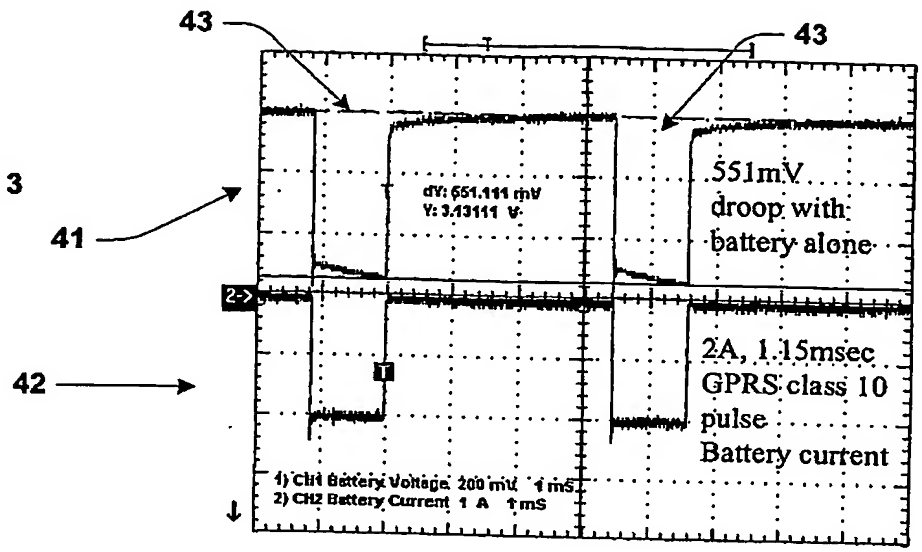


FIGURE 4

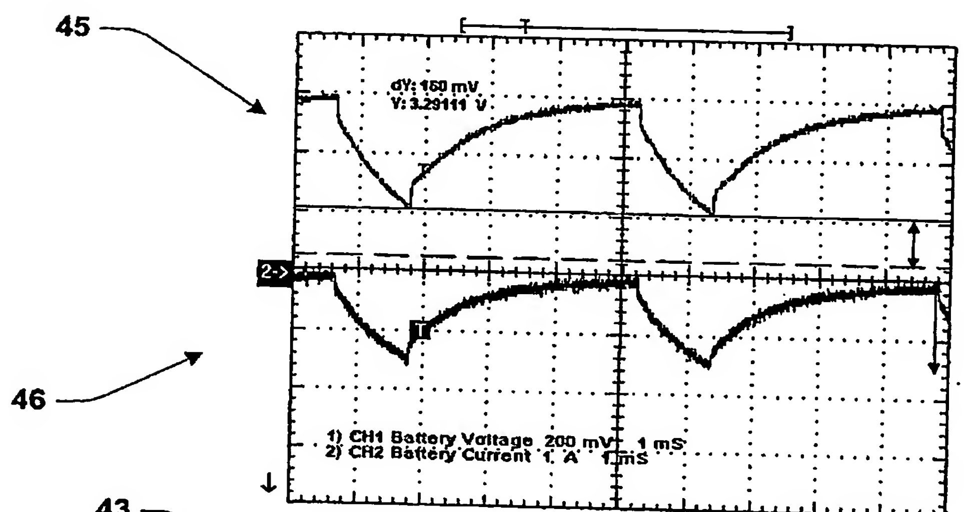
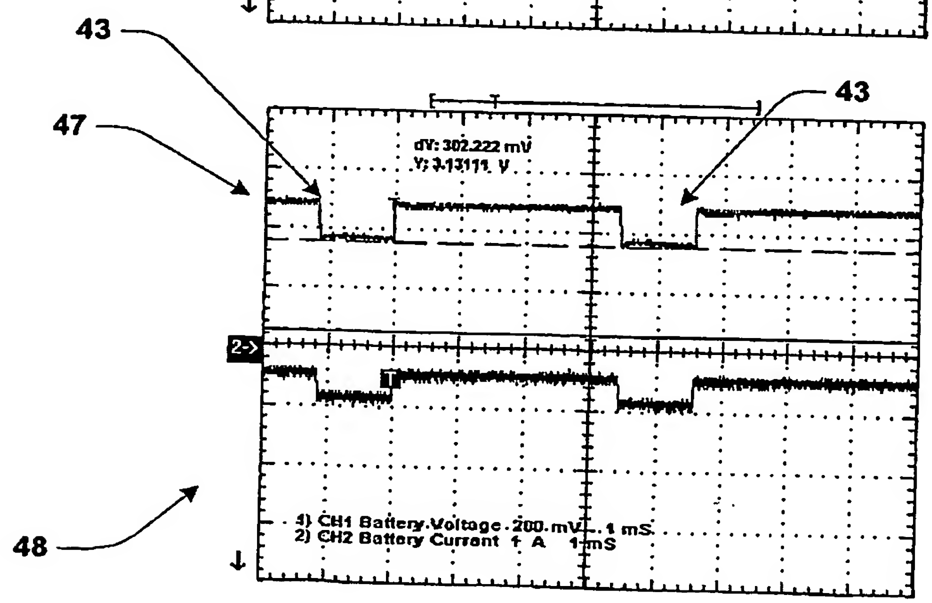


FIGURE 5



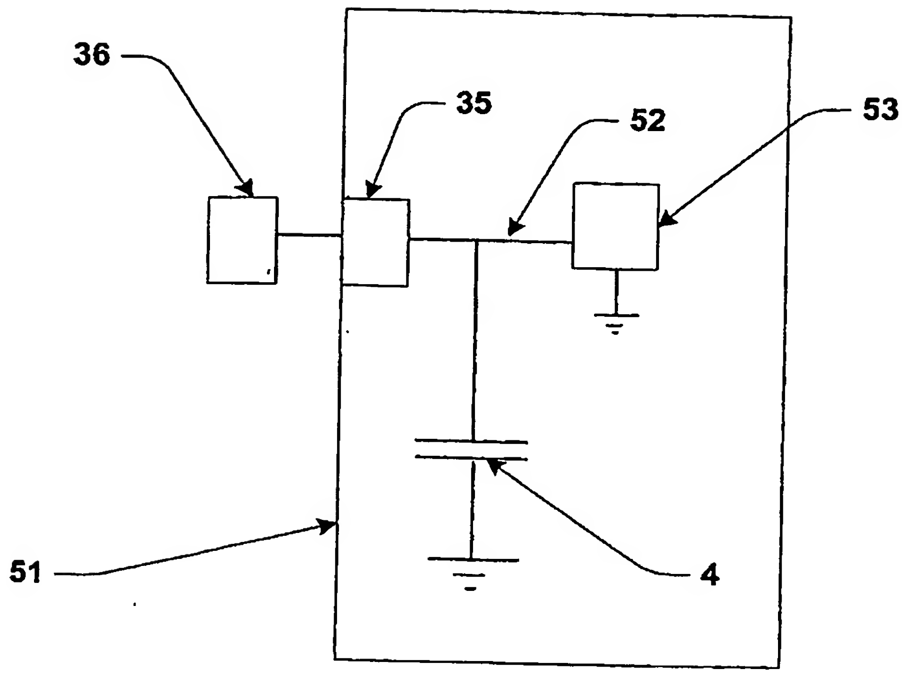


FIGURE 7

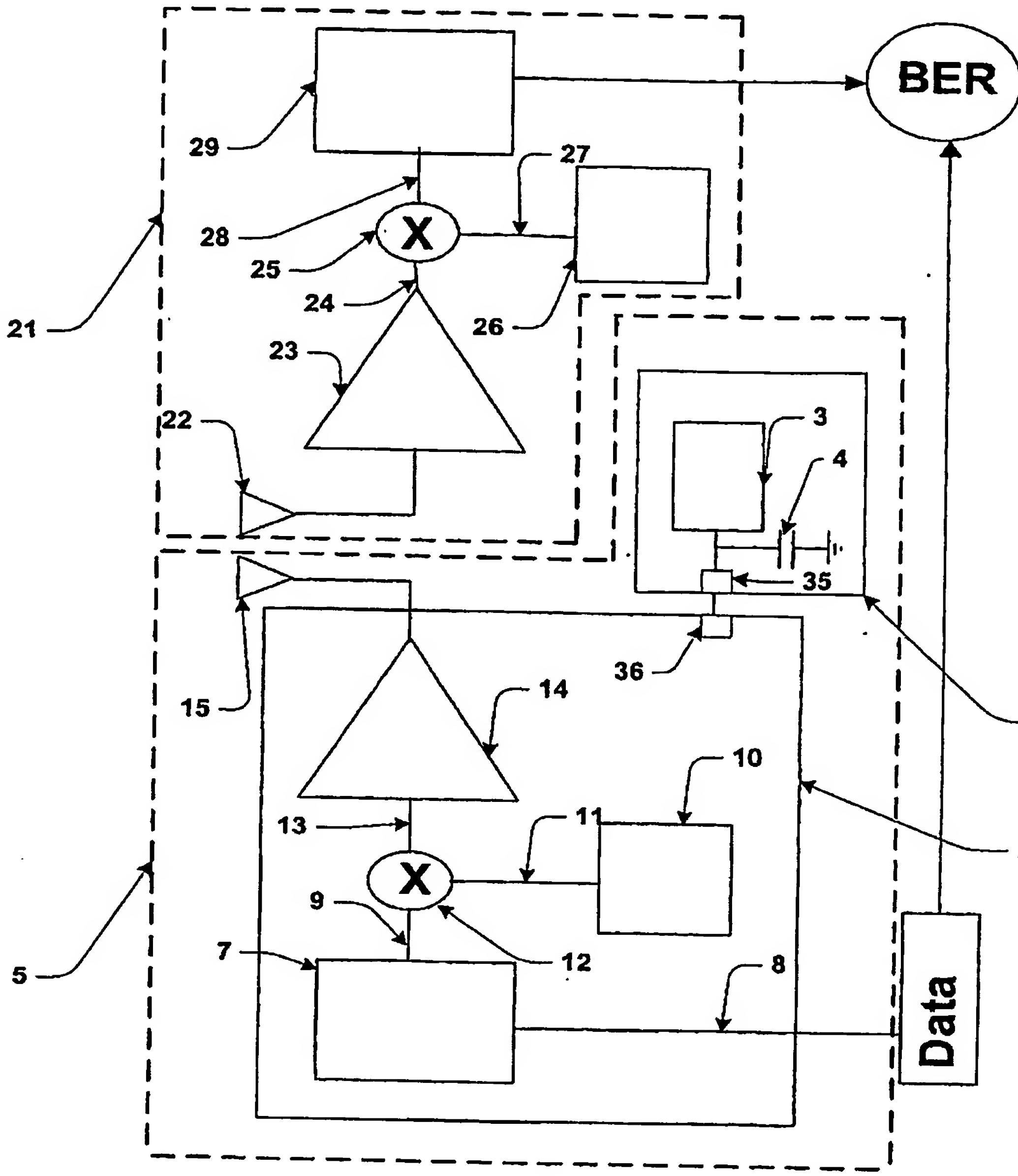


FIGURE 1

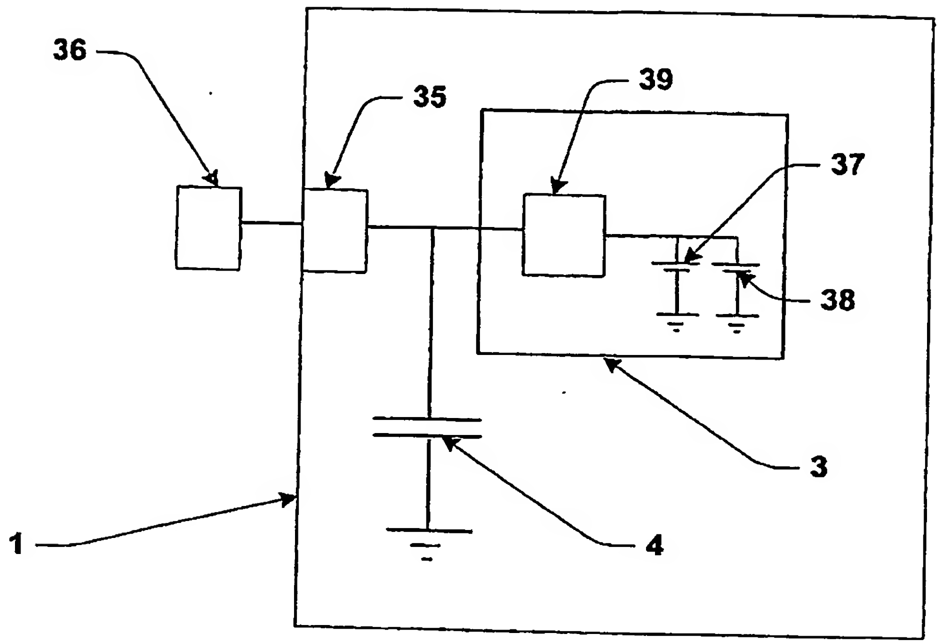


FIGURE 2

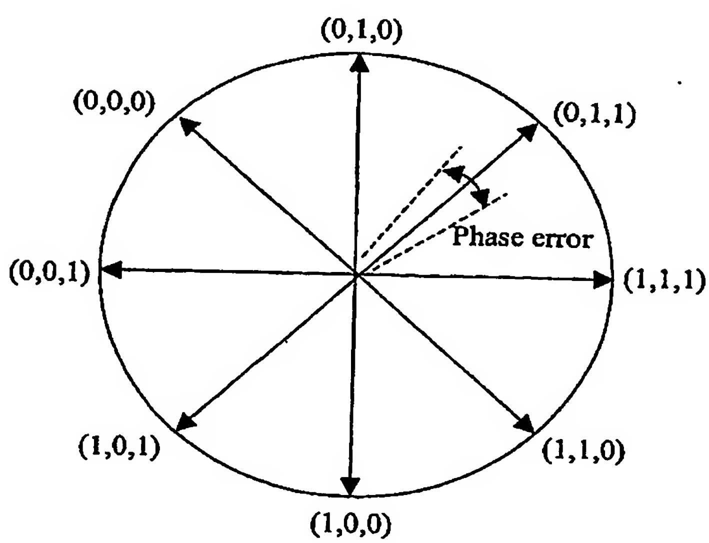


FIGURE 6

FIGURE 3

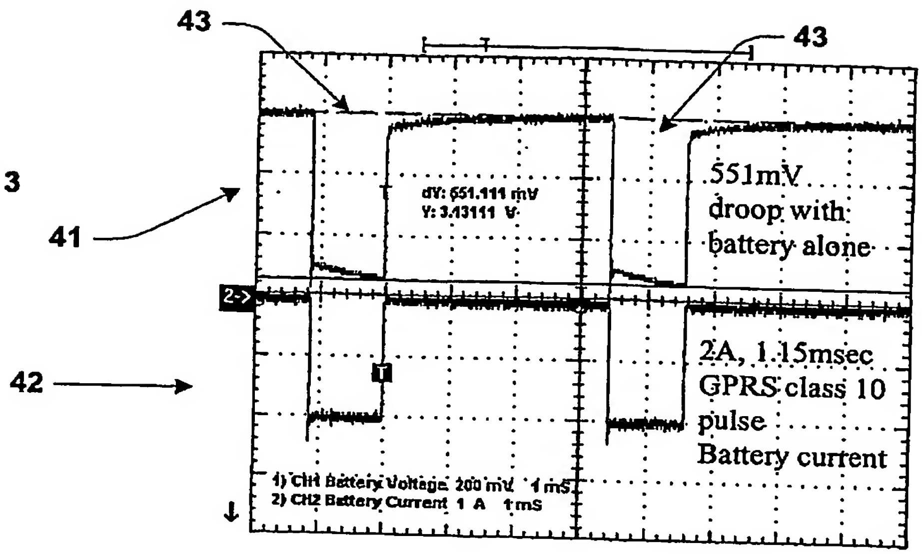


FIGURE 4

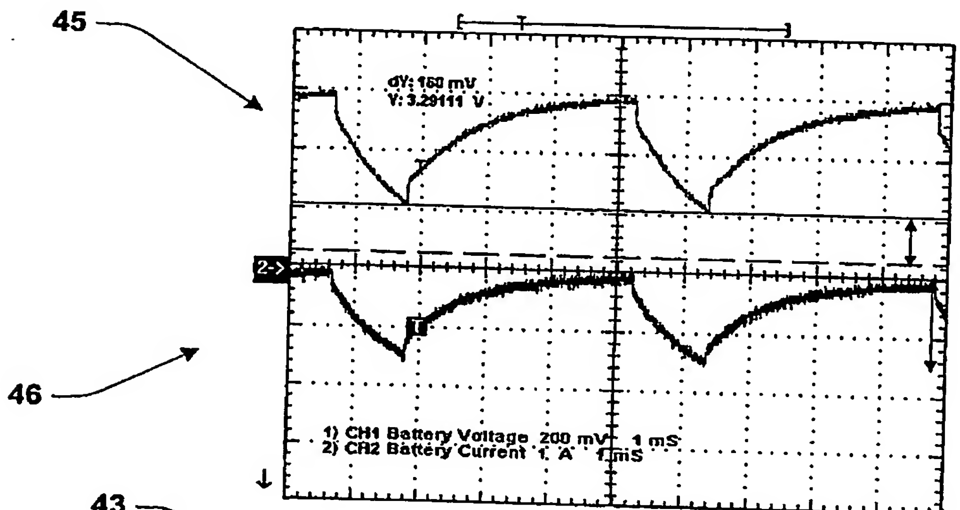
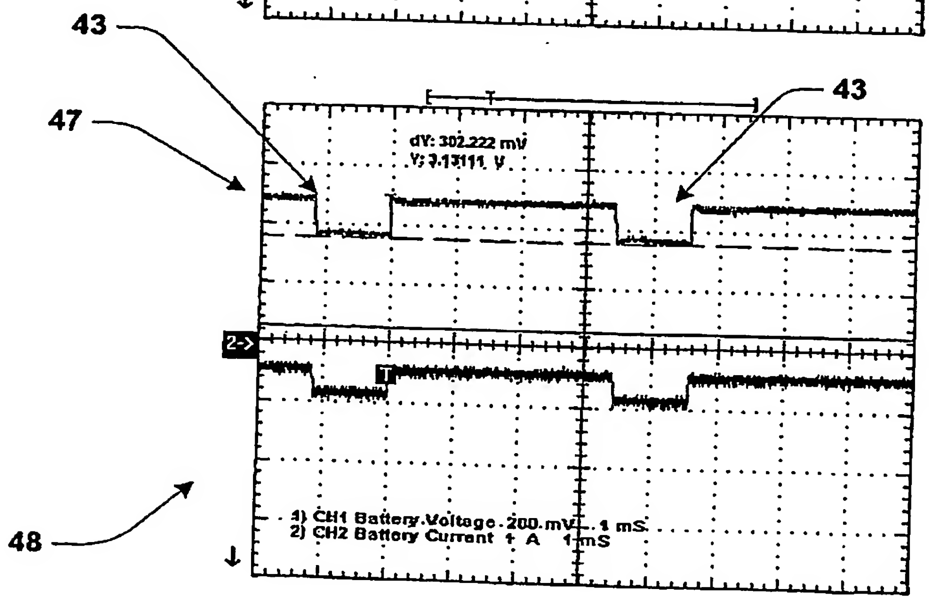


FIGURE 5



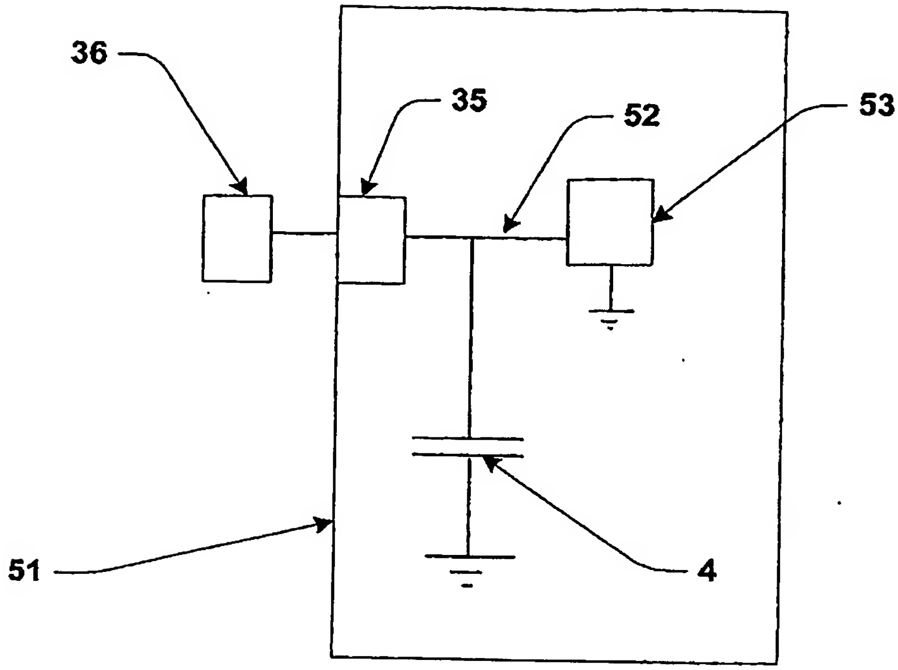


FIGURE 7